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LISTS OF SPECIES

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Checklist of ectoparasitic arthropods among cave-dwelling bats from Marinduque Island, Philippines

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Abstract: This paper constitutes the first ectoparasite faunal survey of bats for Marinduque Island, Philippines. From 1–12 June 2010, 150 bats belonging to 11 species were captured in 11 caves on the island. Each bat was sampled for ectoparasitic arthropods, and a total of 587 individuals representing 21 species, belonging to five families (Acari: Argasidae and Spinturnicidae; Diptera: Nycteribiidae and Streblidae; and Siphonaptera: Ischnopsyllidae) were collected. New host records (**new host record**) in the Philippines for *Brachytarsina cucullata* Jobling 1934, *B. proxima* Jobling 1951, *B. werneri* Jobling 1951, *Raymondia pseudopagodarum* Jobling 1951, *Eucampsipoda philippinensis* Ferris 1924, *Nycteribia allotopa* Speiser 1901, *Nycteribia allotopoides* Theodor 1963, *Nycteribia parvuloides* Theodor 1963, *Ancystropus taprobanius* (Turk 1950), and *Carios batuensis* Hirst 1929 were documented. A checklist of the ectoparasitic species known from the Philippines, their distribution, and bat host species is provided.

Key words: Acari; batflies; Diptera; fleas; Streblidae; mites

INTRODUCTION

Bat ectoparasites constitute a specialized guild of species that have evolved a plethora of morpho-physiological adaptations including usually dorsoventrally flattened bodies, reduced eyesight, and presence of ctenidia and/or setae. They thrive on the wing membranes and bodies of their respective hosts where they feed on blood. There are six insect families known to be ectoparasitic on chiropterans and five of these are exclusively parasitize bats; they are the Arixeniidae (Dermaptera, "bat earwigs") (Nakata & Maa 1974), Polyctenidae (Hemiptera: Heteroptera, "bat bugs"), Nycteribiidae and Streblidae (Diptera, "bat flies"), and Ischnopsyllidae (Siphonaptera, "bat fleas") (Marshall 1982). Although the family Cimicidae is not exclusively ectoparasitic on bats, it contains species such as *Cimex pilosellus* (Horvath, 1910) and *C. pipistrelli* Jenyns, 1839 which are ectoparasitic on bats. Mites and ticks (Acari) are also documented to parasitize bats, including the families Chirodiscidae (Fain 1980), Chirorhynchobiidae (Bochkov et al. 2008), Sarcoptidae (Klompen & O'Connor 1987), Ereynetidae (Fain & Lukoschus 1971), Laelapidae (Shaw 2011), Macronyssidae (Tipton & Boese 1958; Heddergott 2008), Myobiidae (Fain 1979; Uchikawa 1985; Estrada-Peña and De La Cruz 1992), Rosensteiniidae (Durden et al. 1992), Spinturnicidae (Cuy 1980a, 1980b; Delfinado & Baker 1963, Baker & Delfinado 1964), and Argasidae (Durden et al. 2008). Studies on the taxonomy of bat ectoparasites in the Philippine Islands have been few, and among them are those conducted by Jordan & Rothschild (1921), Theodor (1963), Delfinado & Baker (1963), Cuy (1980a, 1980b), Fain (2002), Hastriter (2007), Zabat & Eduardo (2011), Hastriter & Bush (2013), and Alvarez et al. (2015). Throughout the history of bat ectoparasite taxonomy research in the Philippines, Marinduque Island has hitherto remained unstudied. This study aims to document the ectoparasite fauna of cave-dwelling chiropterans in Marinduque Island, especially because of the increasing rate of human disturbance including tourist visits to caves in that province.

MATERIALS AND METHODS

Study site

Bats were captured using 3 × 2.5 m mobile mist nets from 2–11 June 2010. Collections were made in different chambers and along trails in caves at varying elevations on Marinduque Island. Caves were in the municipalities of Boac, Mogpog, Sta. Cruz, and Torrijos (Figure 1; Table 1).

Data collection

Collected host species were identified up to species level. Some specimens were euthanized as voucher specimens by placing them inside ZipLoc™ resealable plastic bags with cotton impregnated with ethyl acetate while others were

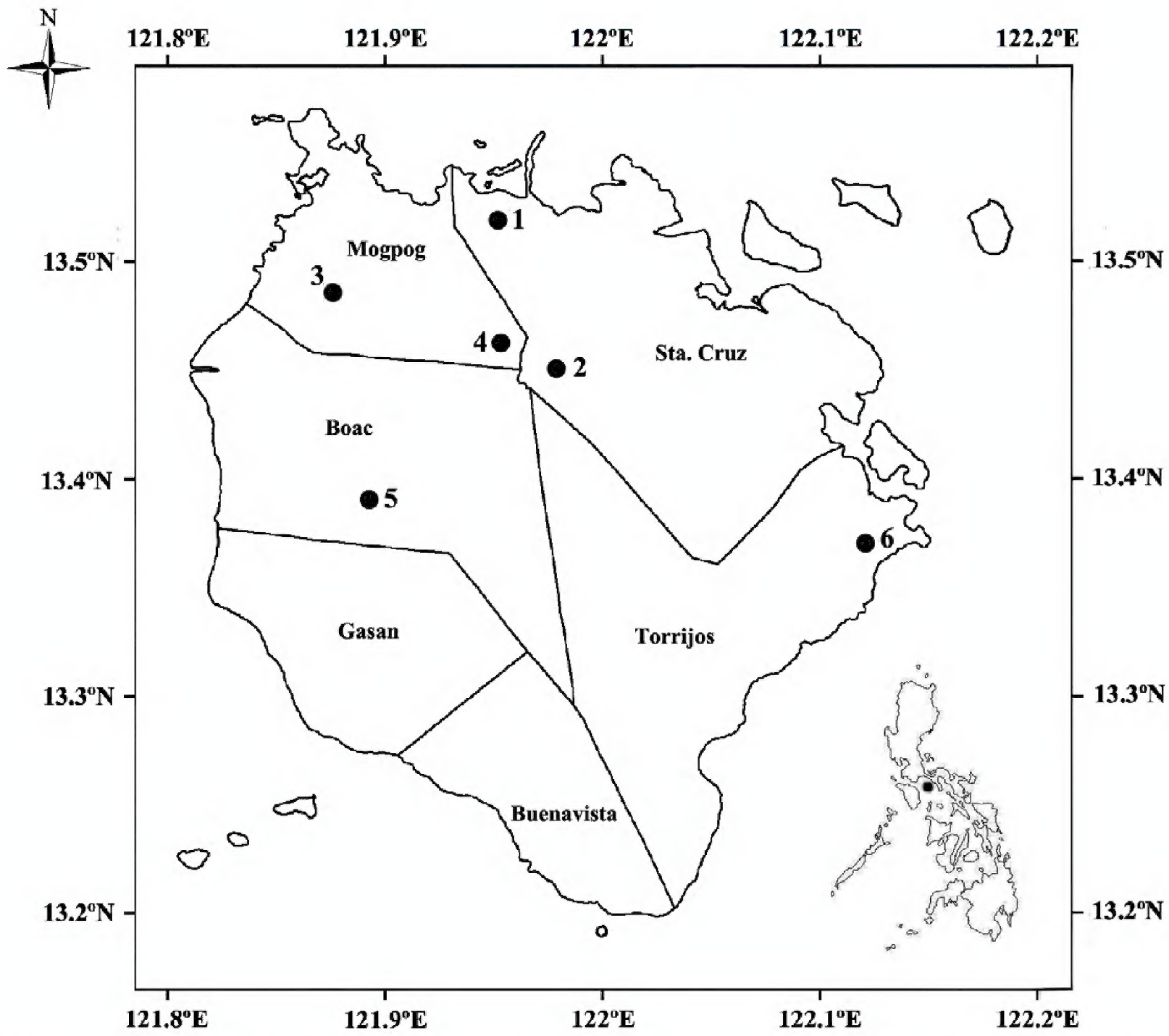


Figure 1. Sampling Sampling sites. 1: Bagongbongan Cave, Barangay Isidro, 2: Lamesa Cave, Barangay Lamesa. 3: Buaya Cave, Barangay Bintakay. 4: Tarug 3+4 cave, Barangay Tarug. 5: Bungoi Cave, Talao 1 and 2 caves, Barangay Duyay. 6: Ka Amundos Cave, Barangay Bonliw.

Table 1. Sampling sites with coordinates and elevation.

Cave	Location	Latitude	Longitude	Elevation (m)
Bagongbongan	Barangay Isidro, Sta. Cruz	13°50′56.6″ N	121°57′04.3″ E	
Lamesa	Barangay Lamesa, Sta. Cruz	13°29′32.1″ N	121°57′05.6″ E	206
Tarug (3+4)	Barangay Tarug, Mogpog	13°30′03.0″ N	121°56′16.9″ E	271
Buaya	Barangay Bintakay, Mogpog	13°29′29.3″ N	121°52′33.6″ E	152
Bungoi	Barangay Duyay, Boac	13°21′34.7″ N	121°53′29.7″ E	357
Talao 1	Barangay Duyay, Boac	13°21′31.1″ N	121°53′31.6″ E	414
Talao 2	Barangay Duyay, Boac	13°21′28.9″ N	121°53′32.9″ E	438
Ka Amundos	Barangay Bonliw, Torrijos	13°21′59.6″ N	121°06′46.6″ E	76

released. The entire dermal surface of the host was examined systematically for the presence of ectoparasites with particular attention to parasitic arthropods, especially on the wing and tail membranes, ventral and dorsal parts of the ears and pelage, toes and wing ridges. Fine-pointed forceps were used to remove the ectoparasites from host animals.

After removal from their hosts, the ectoparasites were counted and specimens placed in 95% ethanol in Eppendorf™ vials that were labeled with place and date of collection as well as host data. To avoid repetitious mention of general collection data in the citations of material examined, all ectoparasites were collected by A.K.S. Amarga and P.A. Alviola in June 2010 from Marinduque Island.

Identifications of ectoparasites were made using a stereomicroscope. Available taxonomic keys to various ectoparasitic taxa infesting bats were used to identify the ectoparasites to the lowest taxonomic level. Voucher specimens of both hosts and ectoparasites were deposited in the University of the Philippines Los Baños, Museum of Natural History (UPLB MNH).

RESULTS

A total of 587 insect and acarine ectoparasites, belonging to five families, were obtained from 150 individuals of cave bats representing 11 species (Table 2). New island and host bat records are also reported.

Table 2. Summary of ectoparasites and their bat hosts from Marinduque Island. New records (✱); present on bat host (+); absent on bat host (–).

Ectoparasites	Hosts									
	Hipposideros diadema	*Megaderma spasma*	*Miniopterus australis*	*Miniopterus schreibersii*	*Rhinolophus arcuatus*	*Rhinolophus philippinensis*	*Rhinolophus rufus*	*Rhinolophus virgo*	*Rhinolophus amplexicaudatus*	*Hipposideros ater*
Brachytarsina amboinensis	+ ✱	+ ✱	+ ✱	+ ✱	+ ✱	–	–	–	–	–
Brachytarsina cucullata	+ ✱	+ ✱	+ ✱	+ ✱	+ ✱	–	–	–	–	–
Brachytarsina sp. A	–	+ ✱	–	–	–	–	–	–	–	–
Brachytarsina proxima	–	+ ✱	–	+ ✱	–	–	–	–	–	–
Brachytarsina werneri	+	+ ✱	+ ✱	+ ✱	+ ✱	–	–	–	–	–
Megastrebla parvior	–	–	–	–	–	–	–	–	–	–
Raymondia pseudopagodarum	–	–	–	+ ✱	–	–	–	–	–	+ ✱
Eucampsipoda inermis	–	–	+	+	+	+	–	–	–	–
Eucampsipoda philippinensis	–	–	–	+	–	–	–	–	–	–
Nycteribia allotopa	–	–	+	+	–	–	–	–	–	–
Nycteribia allotopoides	–	–	+	+	–	–	–	–	–	–
Nycteribia parvula	–	–	+	+	–	–	–	–	–	–
Nycteribia parvuloides	–	–	+	+	–	–	–	–	–	–
Penicillidia acuminata	–	–	+	+	–	–	–	–	–	–
Penicillidia oligacantha	–	–	+	+	–	–	–	–	–	–
Phthiridium brachyacantha	–	–	+	+	–	–	–	–	–	–
Thaumapsylla breviceps	–	–	+	+	–	–	–	–	–	–
Thaumapsylla longiforceps	–	–	+	+	–	–	–	–	–	–
Carios batuensis	–	–	–	–	–	–	–	–	–	–
Ancystropus taprobanius	–	–	–	–	–	–	–	–	–	+ ✱
Meristaspis sp. 1	–	–	–	–	–	–	–	–	–	–

Class Insecta
Subclass Pterygota
Order Diptera
Suborder Brachycera
Division Cyclorrhapha
Superfamily Hippoboscoidea
Family Streblidae Kolenati 1863
Subfamily Brachytarsininae Speiser 1900

Genus *Brachytarsina* Macquart 1851
Brachytarsina Macquart (1851): 280.
Nycteribosca Speiser (1900): 48.

Type species: *Brachytarsina flavipennis* Macquart 1851.

Brachytarsina amboinensis Rondani, 1878
Brachytarsina amboinensis Rondani (1878): 166. Type: host unknown, Amboina, Moluccas; Maa (1965): 383; Delfinado & Hardy (1977): 433.
Nycteribosca amboinensis Speiser (1900): 31.

Documented host records: *Eonycteris spelaea, Hipposideros coronatus, Miniopterus australis, Miniopterus schreibersi, Miniopterus tristis, Rhinolophus* spp., and *Rousettus amplexicaudatus* (Cuy 1980a).

Material examined: on *Hipposideros diadema*: 4♂, ♀; on *M. australis*: ♂, ♀; on *M. schreibersi*: 3♂, ♀; on *Rhinolophus arcuatus*: ♂.

Distribution: Australia; Malaysia (Indonesia (Amboin Island), Myanmar, Philippines (Greater Luzon: Marinduque Island (**new island record**), Polillo Islands, Tablas Island; Greater Mindanao); Japan, Taiwan.

Brachytarsina cucullata (Jobling, 1934)
Nycteribosca cucullata Jobling (1934): 71. Type: male, on *Taphozous melanopogon* Temminck, Matugama state, Kalutara, Ceylon, in Natural History Museum (London); JOBLING (1951): 230; MAA (1962): 433.
Brachytarsina cucullata Maa (1965): 383; Delfinao & Hardy (1977): 433.

Documented host records: *Cynopterus brachyotis*, *Hipposideros diadema* (**new host record**), *Megaderma spasma* (**new host record**), *Miniopterus australis* (**new host record**), *Miniopterus schreibersi*, *Rhinolophus arcuatus* (**new host record**), *Rhinolophus philippinensis* (**new host record**), *Taphozous philippinensis*.

Material examined: on *H. diadema*: 2♀; on *M. spasma*: 2♀; on *M. australis*: 2♂; on *M. schreibersi*: 7♂, 3♀; on *R. arcuatus*: ♂; on *R. philippinensis*: ♂.

Distribution: Malaysia, Philippines (Greater Luzon: Marinduque Island (**new island record**); Greater Mindanao); Sri Lanka.

***Brachytarsina* sp. A**
Brachytarsina sp. A Cuy (1980a): 140

Documented host record: *Megaderma spasma*.

Material examined: on *M. spasma*: 3♂, 4♀.

Distribution: Philippines (Greater Luzon: Bataan, Laguna, Marinduque Island (**new island record**).

Brachytarsina proxima (Jobling, 1951)

Nycteribosca proxima Jobling (1951): 238. Type: on *Rousettus amplexicaudatus* (Geoffroy), Luangbay Cave, Sitio Tegato, Davao City, Mindanao, Philippines; in Field Museum of Natural History (Chicago).

Brachytarsina proxima Maa (1965): 383; Delfinado & Hardy (1977): 433.

Documented host records: *Eonycteris spelaea*, *Hipposideros diadema*, *Megaderma spasma* (**new host record**), *Miniopterus schreibersi* (**new host record**), *Rhinolophus arcuatus*, *Rhinolophus rufus*, *Rousettus amplexicaudatus*.

Material examined: on *M. spasma*: ♂; on *M. schreibersi*: 4♂, ♀; on *R. arcuatus*: 2♂.

Distribution: Philippines (Greater Luzon: Marinduque (**new island record**); Greater Mindanao; Greater Palawan).

Brachytarsina werneri (Jobling, 1951)

Nycteribosca werneri Jobling (1951): 238. Type: on *Hipposideros diadema griseus* (Meyen), Central Cave, Cotabato City, Mindanao, Philippines, in Field Museum of Natural History (Chicago); Maa (1962): 434.

Brachytarsina werneri Maa (1965): 383; Delfinado & Hardy (1977): 434.

Documented host records: *Eonycteris robusta*, *Hipposideros diadema*, *Megaderma spasma* (**new host record**), *Miniopterus australis* (**new host record**), *M. schreibersi* (**new host record**), *Rhinolophus arcuatus* (**new host record**).

Material examined: on *H. diadema*: 2♂, 3♀; on *M. spasma*: 2♂; on *M. australis*: ♂; on *M. schreibersi*: 4♂, 6♀; on *R. arcuatus*: 3♂.

Distribution: Philippines (Greater Luzon: Marinduque Island (**new island record**); Greater Mindanao).

Genus *Megastrebla* Maa, 1971

Megastrebla Maa (1971): 230. Type species: *Nycteribosca nigriceps* Jobling (1934), by original designation. Delfinado & Hardy (1977): 434.

Megastrebla parvior (Maa, 1962)

Nycteribosca gigantea Speiser (1900): 31–70. Type: on *Dobsonia peroni* (Geoffroy), Bismarck Archipelago, in Natural History Museum Giacomo Doria (Genoa); Ferris (1924): 73, *pro parte*; Jobling (1951): 230.

Nycteribosca parvior Maa (1962): 433. Type: on *Eocnycteris spelaea* Dobson, Batu Caves, Selangor, Malaysia, in Bernice Pauahi Bishop Museum (Honolulu).

Brachytarsina parvior Maa (1965): 383.

Megastrebla parvior Maa (1971): 222; Delfinado & Hardy (1977): 434.

Documented host records: *Eonycteris robusta*, *E. spelaea*, *Hipposideros diadema*, *Miniopterus australis*, *M. schreibersi*, *Rousettus amplexicaudatus*.

Material examined: on *Rousettus amplexicaudatus*: 4♂, 5♀.

Distribution: India, Indonesia (Borneo, Java, Sumatra, Sumba), Malaysia, Myanmar, Philippines (Greater Luzon: Marinduque Island, **new island record**; Polillo Islands; Greater Mindanao: Leyte, Samal; Greater Negros-Panay: Negros, Cebu; Greater Palawan: Palawan mainland, Balabac Island).

Genus *Raymondia* Frauenfeld, 1856

Raymondia Frauenfeld (1856): 323–328. Type: *Raymondia huberi* 1855, by subsequent designation of Speiser (1900): 49; Jobling (1930): 283; Jobling (1951): 228; Maa (1962): 435; Maa (1965): 384; delfinado & Hardy (1977): 434.

Raymondia pseudopagodarum Jobling, 1951

Raymondia pseudopagodarum Jobling (1951): 241. Type: on *Rhinolophus* sp., Cantor, Sitio Tegato, Davao City, Mindanao, Philippines; Maa (1962): 435; Maa (1965): 384; Delfinado & Hardy (1977): 434.

Documented host records: *Emballanura alecto* (**new host record**), *Eonycteris spelaea*, *Hipposideros ater* (**new host record**), *Hipposideros galeritus*, *Miniopterus australis*, *Miniopterus schreibersi*, *Rhinolophus arcuatus*, *Rhinolophus philippinensis* (**new host record**), *Rhinolophus rufus*, *Rhinolophus virgo*.

Material examined: on *E. alecto*: ♂; on *H. ater*: 2♀; on *M. australis*: ♂, ♀; on *M. schreibersi*: 2♂; on *R. philippinensis*: 4♂.

Distribution: China; Indonesia (Borneo), Malaysia, Myanmar, Philippines (Greater Luzon: Marinduque (**new island record**); Greater Mindanao; Greater Negros-Panay: Negros Island; Greater Palawan: mainland Palawan).

Family Nycteribiidae Samouelle, 1819
Subfamily Cyclopodiinae Maa, 1965

Genus *Eucampsipoda* Kolenati, 1857

Eucampsipoda Kolenati (1857): 62. Type species: *Nycteribia hyrtlii* Kolenati (1856), by subsequent designation of Theodor (1955): 196; Theodor (1955): 196; Maa (1962): 426; Maa (1965): 380; Delfinado & Hardy (1977): 420.

Eucampsipoda inermis Theodor, 1955

Eucampsipoda inermis Theodor (1955): 215. Types: on *Eonycteris spelea glandifera* and *Rousettus amplexicaudatus*, Soribao, Borongan, Samar, Philippines, in Natural History Museum (London); Theodor (1963): 180; Maa, (1962): 426; Maa (1965): 379; Delfinado & Hardy (1977): 420.

Documented host records: *Eonycteris spelaea*, *Rousettus amplexicaudatus*.

Material examined: on *R. amplexicaudatus*: 2♀.

Distribution: Australasian: Northeastern New Guinea; Oriental: Indonesia (Java, Sumba), Malaysia, Myanmar, Philippines (Greater Luzon: Catanduanes; Marinduque Island (**new island record**); Mindoro; Polillo Islands; Greater Mindanao: Leyte, mainland Mindanao, Samal Island, Samar; Greater Negros-Panay: Cebu, Negros; Greater Palawan: Balabac Island, Busuanga Island, mainland Palawan; Greater Sulu: Jolo.

Eucampsipoda philippinensis Ferris, 1924

Eucampsipoda philippinensis Ferris (1924): 76. Type: female, on undetermined bat, Montalban, Rizal, Luzon, Philippines; in National Museum of Natural History (Washington, DC).; Theodor (1955): 210; Theodor 91963): 178; Maa (1965): 379; Delfinado & Hardy (1977): 421.

Documented host records: *Eonycteris robusta*, *Hipposideros diadema*, *Miniopterus schreibersi*, *Rousettus amplexicaudatus*.

Material examined: on *M. schreibersi*: 4♂, ♀; on *R. amplexicaudatus*: 2♂, 2♀.

Distribution: Philippines (Greater Luzon: Marinduque (**new island record**), Mindoro, Polillo Islands, Rizal; Greater Mindanao: Leyte, mainland Mindanao; Greater Negros-Panay: Negros Island.

Genus *Nycteribia* Latreille, 1796

Nycteribia Latreille (1796): 76. Type species: *Nycteribia pedicularia* Latreille 1805, by designation under the Plenary powers of ICZN, Opinion 128: 493; Speiser (1901): 11; Maa (1962): 417; Maa (1965): 381; Delfinado & Hardy (1977): 427.

Listripoda Kolenati (1857): 62. Type species: *Listripoda blassi* Kolenati 1856, by subsequent designation of Coquillet (1910): 562.

Acrocholidia Kolenati (1857): 62. Type species: *Acrocholidia bechsteini* Kolenati 1857, by subsequent designation of Coquillet (1910): 502.

Nycteriphila Grulich & Povolny (1955): 116-128. Type species: *Nycteribia schimidlii* Schiner 1853, by original designation.

Nycteribia allotopa Speiser, 1901

Nycteribia allotopa Speiser (1901): 47. Type: host unknown, Cave at Lian si Paghe, West Sumatra, in Natural History Museum Giacomo Doria (Genoa); Ferris (1924): 397; Theodor (1963): 152; Maa (1965): 382; Delfinado & Hardy (1977): 427.

Nycteribia insolita Scott (1908): 364. Type: male, on *Miniopterus schreibersii*, Tainan, Formosa, in Natural History Museum (London).

Listropodia wui Hsu (1935): 295. Type: male, host unknown, Soochow, China, repository unknown.

Documented host records: *Megaderma spasma* (**new host record**), *Miniopterus australis*, *Miniopterus schreibersi*, *Pipistrellus imbricatus*, *Rhinolophus arcuatus* (**new host record**), *Rhinolophus philippinensis* (**new host record**); *Rhinolophus virgo* (**new host record**), *Tadarida luzonus*.

Material examined: on *M. spasma*: ♂; on *M. australis*: 16♂, ♀; on *M. schreibersi*: 10♂, 5♀; on *R. arcuatus*: ♂; on *R. philippinensis*: ♂; on *R. virgo*: ♂.

Distribution: India, Indonesia (Java, Sumatra), Philippines (Greater Luzon: Marinduque (**new island record**), Polillo Islands; Greater Palawan).

Nycteribia allotopoides Theodor, 1963

Nycteribia allotopoides Theodor (1963): 157. Type: male, ex *Miniopterus* sp., Luangbay Cave, Sitio Tegato, Davao City, Mindanao, Philippines, in Field Museum of Natural History (Chicago); Maa (1965): 382; Delfinado & Hardy (1977): 427.

Documented host record: *Megaderma spasma* (**new host record**), *Miniopterus australis*, *Miniopterus schreibersi*, *Myotis macrotarsus*, *Rhinolophus philippinensis* (**new host record**).

Material examined: on *M. spasma*: ♂; on *M. australis*: 11♂, 2♀; on *M. schreibersi*: 9♂, 2♀; on *R. philippinensis*: ♂.

Distribution: Myanmar, Philippines (Greater Luzon: Marinduque Island (**new island record**), Polillo Islands; Greater Mindanao).

Nycteribia parvula Speiser, 1901

Nycteribia parvula Speiser (1901): 48. Type: host unknown, Cave at Lian si Paghe, West Sumatra, in Natural History Museum Giacomo Doria (Genoa); Ferris (1924): 399; Theodor (1963): 158; Maa (1965): 382; Delfinado & Hardy (1977): 427.

Documented host record: *Chaerephon plicata*, *Miniopterus australis*, *Miniopterus schreibersi*, *Rhinolophus arcuatus*.

Material examined: on *M. australis*: 7♂, 5♀; on *M. schreibersi*: 12♂, 7♀.

Distribution: Australasian: New Guinea; Oriental: Afghanistan, India, Indonesia (Amboina, Java, Moluccas, Sumatera), Myanmar, Pakistan, Philippines (Greater Luzon: Marinduque (**new island record**), mainland Luzon, Polillo Islands; Greater Mindanao: mainland Mindanao, Tablas); Palaeotropic: Japan.

Nycteribia parvuloides Theodor, 1963

Nycteribia parvuloides Theodor (1963): 162. Type: male, ex *Miniopterus* sp., Luangbay Cave, Sitio Tegato, Davao City, Mindanao, Philippines, in Field Museum of Natural History (Chicago); Maa (1965): 382; Delfinado & Hardy (1977): 427.

Documented host record: *Eonycteris spelaea*, *Hipposideros coronatus*, *Miniopterus australis*, *M. schreibersi*, *Rhinolophus arcuatus* (**new host record**), *Rhinolophus virgo* (**new host record**), *Rousettus amplexicaudatus*.

Material examined: on *M. australis*: 5♂, 3♀; on *M. schreibersi*: 7♂, 3♀; on *R. arcuatus*: ♂; on *R. virgo*: ♂.

Distribution: Australasian: Nicobar Island; Oriental: Malaysia, Myanmar, Philippines (Greater Luzon: Marinduque Island (**new island record**), Polillo Islands; Greater Mindanao).

Genus *Penicillidia* Kolenati, 1863

Megistropoda Kolenati (1857): 62

Penicillidia Kolenati (1863): 69. Type species: *Nycteribia dufourii* Westwood 1834, by subsequent designation of Speiser (1901): 32; Maa (1962): 422; Maa (1965): 379; Delfinado & Hardy (1977): 428.

Penicillidia acuminata Theodor, 1963

Penicilldia oceanica acuminata Theodor (1963): 174. Type: ex *Rhinolophus* and *Miniopterus* spp., Miatan Cave, Katipunan, Zamboanga, Mindanao, Philippines; in Field Museum of Natural History (Chicago).

Penicillidia acuminata: Maa (1965): 374; Delfinado & Hardy (1977): 428.

Documented host record: *Chaerephon plicata*, *Emballanura alecto*, *Miniopterus australis*, *Miniopterus schreibersi*.

Material examined: on *M. australis*: 2♂, 2♀; on *M. schreibersi*: 8♂, 4♀.

Distribution: Oriental: Indonesia (Java), Philippines (Greater Luzon: Lubang, Marinduque (**new island record**), Polillo Island; Greater Mindanao).

Penicillidia oligacantha Theodor, 1963

Penicillidia oligacantha Theodor (1963): 171. Type: male, on *Miniopterus* sp., Luangbay Cave, Sitio Tegato, Davao City, Mindanao, Philippines, in Field Museum of Natural History (Chicago); Maa (1965): 379; Delfinado & Hardy (1977): 428.

Documented host record: *Eonycteris spelaea*, *Miniopterus australis*, *Miniopterus schreibersi*, *Rousettus amplexicaudatus*.

Material examined: on *M. schreibersi*: 3♂, ♀.

Distribution: Oriental: Philippines (Greater Luzon: Marinduque Island (**new island record**), Polillo Island; Greater Mindanao).

Genus *Phthiridium* Hermann, 1804

Phthiridium Hermann (1904): 12. Type species: *Phthiridium biarticulatum* Hermann 1804, by subsquent designation of Coquillet (1910): 590; Maa (1965): 381; Delfinado & Hardy (1977): 429.

Phthiridium brachyacantha Theodor, 1963

Stylidia brachyacantha Theodor (1963): 164. Type: male, host, unknown, Caburan, Davao, Mindanao, Philippines, in Field Museum of Natural History (Chicago).

Phthiridium brachyacantha Maa (1965): 381; Delfinado & Hardy (1977): 429.

Host record: Known only from *Rhinolophus* spp.

Material examined: On *Rhinolophus arcuatus*: 1♂.

Distribution: Oriental: Philippines (Greater Luzon: Marinduque, (**new island record**); Greater Mindanao).

Order Siphonaptera

Family Ischnopsyllidae Wahlgren, 1907

Genus *Thaumapsylla* Rothschild, 1907

Thaumapsylla Rothschild (1907): 329. Type species: *Thaumapsylla breviceps* Rothschild, 1907.

Thaumapsylla breviceps Rothschild, 1907

Thaumapsylla breviceps Rothschild (1907): 329.

Documented host record: Known only to infest fruitbats (Pteropodidae)

Material examined: *Rousettus amplexicaudatus*: 3♂, 4♀.

Distribution: Ethiopian region (Afrotropical); Oriental: Philippines (Greater Luzon: mainland Luzon, Marinduque (**new island record**), Mindoro).

Thaumapsylla longiforceps Traub, 1951

Thaumapsylla longiforceps Traub (1951): 15.

Documented host record: Known only to infest fruitbats (Pteropodidae).

Material examined: *Rousettus amplexicaudatus*: ♂, 2♀.

Distribution: Oriental: Philippines (Greater Luzon: Laguna, Marinduque (**new island record**); Greater Mindanao: Davao, Leyte).

Class Arachnida

Subclass Acari

Order Ixodida

Family Argasidae Koch, 1844

Genus *Carios* Latreille, 1796

Carios Latreille (1796): 176.

Carios batuensis Hirst, 1929

Carios batuensis Hirst (1929): 365.

Documented host record: Known to be ectoparasitic on Pteropodidae.

Material examined: *Rousettus amplexicaudatus*: ♂, 2♀.

Distribution: Oriental: Philippines (Marinduque (NCR and **new island record**), Indonesia (Sulawesi).

Family Spinturnicidae Oudemans, 1902

Genus *Ancystropus* Kolenati, 1856

Ancystropus Kolenati (1856): 1; Rudnick (1960): 171.

Ancystropus taprobanius Turk, 1950

Meristaspis taprobanius Turk (1950): 73. Type: female, on *Rousettus seminudus* (Gray), Rattota, Matale District, Ceylon, in G. Thompson & F.A. Turk collection.

Ancystropus taprobanius: Rudnick (1960): 177.

Ancystropus indicus Hiregauder & Bal (1955): 221 (*nom. nud.*). Type: ex *Rousettus leschenaulti*, Jogeshwari and Kanheri Caves, Bombay, in Hiregauder & Bal collection, Institute of Science, Mumbai. Domrow 1972).

Ancystropus rudnicki Baker & Delfinado (1964): 577. Type: female, on unknown bat, Sum-Sum, New Guinea, in Bernice Pauahi Bishop Museum (Honolulu). Domrow 1972).

Documented host record: *Cynopterus brachyotis* and *Rousettus amplexicaudatus*.

Material examined: on *Hipposideros ater*: ♀; on *Miniopterus schreibersi*: ♀; on *Rhinolophus arcuatus*: ♂; on *Rousettus amplexicaudatus*: 2♂, 2♀.

Distribution: Australasian: Papua New Guinea; Oriental: India, Laos, Philippines (Greater Luzon: Laguna, Marinduque Island (**new island record**); Greater Negros-Panay: Cebu, Negros Oriental), Sri Lanka.

Genus *Meristaspis* Kolenati, 1857

Meristaspis Kolenati (1857): 60; Rudnick (1960): 178.

***Meristaspis* sp. 1**

Documented host record: The genus is known to infest members of the family Pteropodidae.

Material examined: *Rousettus amplexicaudatus*: ♀.

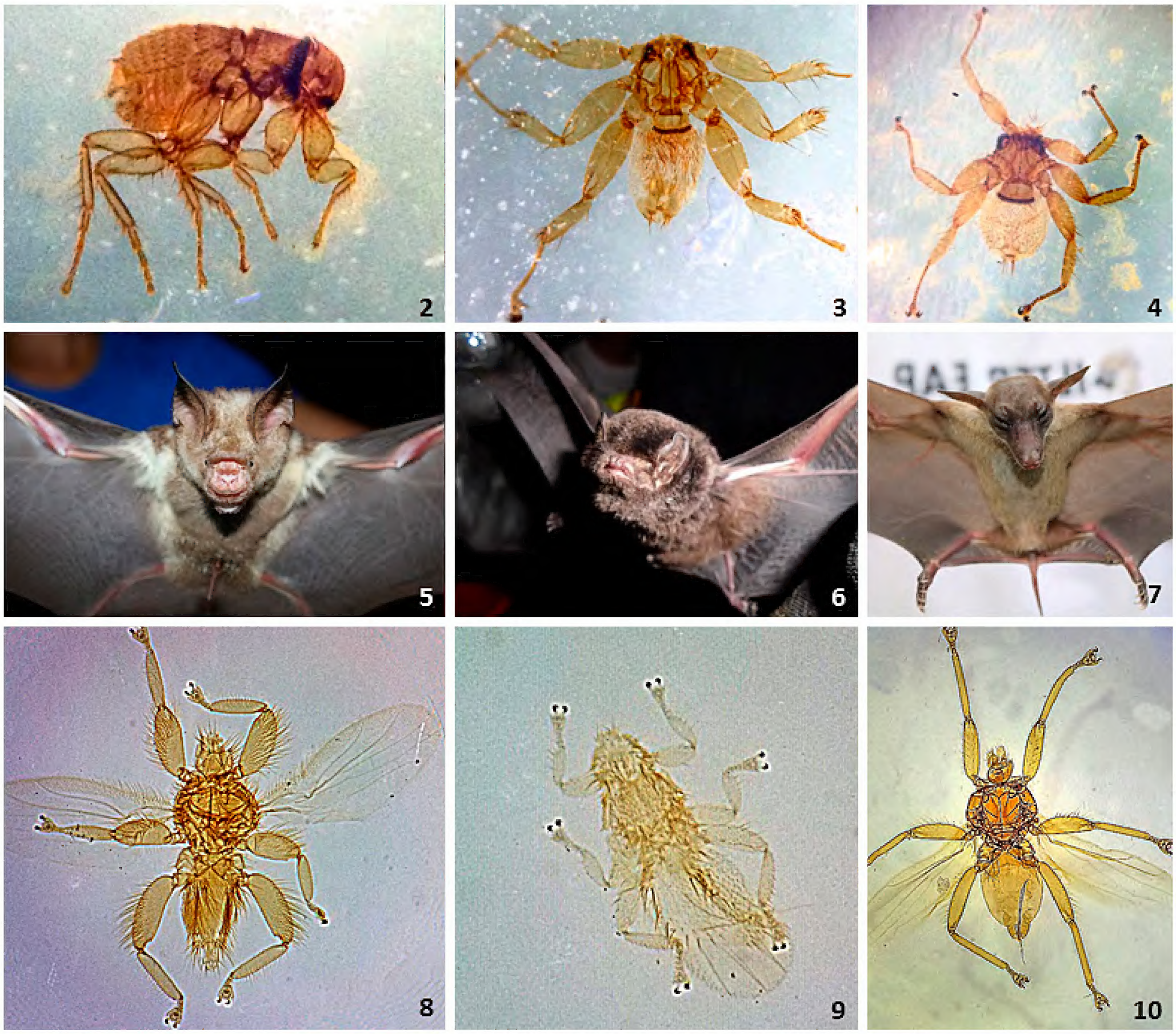
Distribution: Oriental: Philippines (Marinduque Island [**new island record**]).

DISCUSSION

This paper presents the first faunal survey of bat ectoparasites in Marinduque Island, and therefore, all taxa documented herein are new island records. Among the recorded families, Streblidae, Nycteribiidae, Ischnopsyllidae, and Spinturnicidae (Delfinado & Baker 1963; Dittmar et al. 2006; Krasnov 2008) are restricted only to bats, whereas the Argasidae tend to have a much broader host specificity in various terrestrial vertebrate groups (Estrada-Peña et al. 2010; Barros-Battesti et al. 2015).

The Ischnopsyllidae is the only siphonapteran family exclusively associated with bats (Smit 1957; Krasnov 2008). Bat fleas are traditionally divided into two subfamilies: Thaumapsyllinae (parasitic to Megachiorptera), and Ischnopsyllinae (parasitic to microchipterans) (Whiting et al. 2008). Of the three bat flea genera known to occur in the Philippines, only *Thaumapsylla* (Figure 2) was documented in Marinduque and was known to be associated with pteropodids.

Nycteribiidae are apterous batflies with arachnoid habitus and is most specious in the Old World (Hutson 1984). Currently, there are three recognized subfamilies known in literature, but only two, Cyclopodiinae and Nycteribiinae,



Figures 3–9. Some ectoparasitic arthropods, and bat hosts, from Marinduque Island, Philippines. **2.** *Thaumapsylla breviceps* Rothschild, bat flea found in fruit-eating bats. **3.** Nycteribiid bat fly *Eucampsipoda sundaica*. **4.** Nycteribiid bat fly *Nycteribia parvula*. **5.** Bat host *Hipposideros diadema*. **6.** Bat host *Miniopterus schreibersii*. **7.** Bat host *Rousettus amplexicaudatus*. **8.** Streblid batfly, *Brachytarsina amboinensis*. **9.** Streblid batfly, *Raymondia pseudopagodarum*. **10.** Streblid batfly, *Megastrebla parvior*.

occur in the Philippines (Maa 1962; Theodor 1963; Cuy 1980b). In this paper, four genera were recorded: *Eucampsipoda* (Figure 3), *Nycteribia* (Figure 4), *Penicillidia*, and *Phthiridium*. *Eucampsipoda* is exclusively associated with Pteropodidae (Maa 1962) whereas the latter three genera are known to be associated with microchiropterans (Theodor 1963).

The family Streblidae is usually found on insect-eating bats (Figure 5–6) and is only infrequently found on fruit-eating bats (Figure 7) (Maa 1971), which was corroborated here. The genera *Brachytarsina* (as documented on Hipposideridae, Megadermatidae, Rhinolophidae, Vespertilionidae) (Figure 8) and *Raymondia* (as documented on *Emballanura alecto*) (Figure 9) were found in bat families belonging to the suborder Microchiroptera. The genus *Megastrebla* (Figure 10) is entirely ectoparasitic on cave-dwelling Megachiroptera, including *Dobsonia*, *Eonycteris*, and *Rousettus* (Maa 1971). In this study, *Megastrebla* was recorded only in *Rousettus amplexicaudatus*. The streblid fauna is predominantly Indo-Malayan with endemicity of 50% at the species level (Amarga et al. 2015).

Spinturnicidae (Acarina) comprises mites that are exclusively ectoparasitic on bats. Four genera occur in the Philippines and two of them, *Ancystropus* and *Meristaspis*, are documented in Marinduque Island. In the Philippines, the genus *Ancystropus* is known only from pteropodids (Cuy 1979; Delfinado & Baker 1963). New host records for *Ancystropus taprobanius* include microchiropterans (*Rhinolophus, Hipposideros*, and *Miniopterus*). The genus *Meristaspis* was documented on the family Pteropodidae (Cuy 1979), and in Marinduque, it was collected from *Rousettus amplexicaudatus*.

New host records in the Philippines for *Brachytarsina cucullata* (on *Hipposideros diadema griseus*, *Megaderma spasma*, *Miniopterus australis*, *Rhinolophus philippinensis*, and *Rhinolophus arcuatus*), *Brachytarsina proxima* (on *Miniopterus schreibersi* and *Meg. spasma*), *Brachytarsina werneri* (on *M. australis*, *M. schreibersi*, *Meg. spasma*, and *R. arcuatus*), *Raymondia pseudopagodarum* (on *R. philippinensis*, *Hipposideros ater*, and *Emballanura alecto*), *Eucampsipoda philippinensis* (on *M. schreibersi*), *Nycteribia allotopa* (on *Rhinolophus* sp. and *Meg. spasma*), *Nycteribia allotopoides* (on *Meg. spasma* and *R. philippinensis*), *Nycteribia parvuloides* (*R. arcuatus* and *R. virgo*), *Ancystropus taprobanius* (on *R. arcuatus, H. ater*, and *M. schreibersi*) and *Carios batuensis* (on *Rousettus amplexicaudatus*).

This is the first study of the first faunal surveys in the Philippines which addresses only the ectoparasite diversity of cave-dwelling chiropterans. Previous studies of the bat ectoparasite fauna of Philippine bats also included non-cave dwelling bats (Theodor 1963; Delfinado & Baker 1963; Cuy 1979, 1980a, 1980b; Hastriter & Bush 2013).

Ectoparasites are integral components of the ecosystem and to some extent may portray the role of keystone species. They have evolved in parallel with their host taxa over time. Their variety of host specificity spectrum ranging from monoxeny to polyxeny can also be used to elucidate their evolutionary radiation within the host taxa. Bat ectoparasites are important groups that should be studied in documenting Philippine biodiversity.

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